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AVSCOM PROJECT NOS. 72-31 and 72-34
USAASTA PROJECT NOS. 72-31 and 72-34

SIDEWARD FLIGHT, HIGH-ALTITUDE EVALUATION, AND SIMULATED ENGINE FAILURES KINGCOBRA MODEL 309 ATTACK HELICOPTER

FINAL REPORT

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AUGUST 1972

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ABSTRACT

The US Army Aviation Systems Test Activity conducted a limited evaluation of the performance and handling qualities of the Bell Helicopter Company Model 309 helicopter at Arlington, Texas, and Alamosa, Colorado, a high-altitude site, during the period 11 July to 8 August 1972. The evaluation required 7 hours of flight time. Previous testing had been accomplished at the contractor's facility during the period 5 June to 6 July 1972 and a report was submitted. Except as noted in this report, the performance and handling qualities were essentially unchanged from those observed during the previous testing. The tail rotor horsepower limitation previously reported as a deficiency no longer exists due to an uprating of the tail rotor drive system from 350 to 450 shaft horsepower. The increase in sideward flight airspeeds to 60 knots in left sideward flight and 50 knots in right sideward flight at low altitude, and 50 and 40 knots in left and right sideward flight at high altitude, enhances the ability to hover in gusty winds. The standard-day out-of-ground-effect hover ceiling at the TOW mission gross weight of 12,385 pounds is 14,340 feet and at the maximum allowable gross weight of 14,000 pounds, is 9950 feet. The hot day (95°F) out-of-ground-effect ceiling is 4300 feet at maximum gross weight. Lateral acceleration maneuvers were conducted at both high- and low-altitude sites. Left lateral acceleration was limited by the transmission torque limit to 0.33g at the low-altitude site and 0.24g at the high-altitude site. Right lateral accelerations were limited by directional control to 0.28g and 0.14g at the low- and high-altitude sites, respectively. The helicopter response characteristics following simulated engine failures were significantly milder than that of the standard AH-1G and are satisfactory. One shortcoming, the excessive pilot workload during lateral accelerations and reversals, was identified.

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INTRODUCTION

BACKGROUND

1. The Model 309 KingCobra is a prototype attack helicopter designed and built by Bell Helicopter Company (BHC) under an in-house funded program independent of any military requirement. The design phase was completed and construction was begun in February 1971. The first flight of the Model 309 was on 27 January 1972. The US Army Aviation Systems Test Activity (USAASTA) was tasked by the US Army Aviation Systems Command (AVSCOM) to conduct an evaluation of the Model 309 helicopter to support the Attack Helicopter Requirement Evaluation (AHRE) performed by the US Army Combat Developments Command (ref 1, app A). Test results were published in USAASTA Project Report No. 72-10, July 1972 (ref 2). Further testing was requested by AVSCOM Test Directive No. 72-31, 20 July 1972 (ref 3) and AVSCOM Test Directive No. 72-34, 4 August 1972 (ref 4).

TEST OBJECTIVES

2. The objectives of this Model 309 attack helicopter evaluation were to determine the hover and sideward flight characteristics at an elevation of at least 7000 feet, and to determine sideward flight and simulated engine failure characteristics at a low elevation.

DESCRIPTION

3. The BHC Model 309 KingCobra helicopter is essentially a growth version of the AH-1G. The main rotor blades have double swept tips, a Wortmann airfoil, a wider chord, and increased diameter as compared to the AH-1G. The automatic flight control stabilization system (AFCS) incorporates a three-axis stability and control augmentation system (SCAS) and an attitude retention unit (ARU). The power plant is a Lycoming T55-L-7C turboshaft engine rated at 2850 shaft horsepower (shp) at sea-level (SL), static conditions. The engine is limited to 2050 shp due to the helicopter main transmission limitation. The maximum gross weight of the BHC Model 309 is 14,000 pounds. A detailed description of the Model 309 can be found in appendixes B and C of reference 2, appendix A.

SCOPE OF TEST

4. The BHC Model 309 was evaluated at the Arlington, Texas, plant (elevation 630 feet) of BHC from 11 July to 13 July 1972, and

8 August 1972, and at Alamosa, Colorado, (elevation 7535 feet) from 21 July to 26 July 1972. During this evaluation, 12 test flights were conducted for a total of 7 flight hours. Performance testing was conducted with the environmental control unit (ECU) OFF. Test configurations consisted of the following: clean (no external stores); external stores (two XM159C pods on each wing with rockets installed to achieve the desired gross weight); and TOW mission (simulated by the external stores configuration and a gross weight of 12,385 pounds). Test conditions are shown in table 1.

5. The flight restrictions and operating limitations applicable to this evaluation are contained in the pilot's checklist (ref 5, app A) as modified by the safety-of-flight release (refs 6 through 11).

METHODS OF TEST

6. Established flight test techniques and data reduction procedures were used (refs 12 and 13, app A). The test methods are briefly described in the Results and Discussion section of this report. A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app B). Data analysis methods utilized are described in reference 2, appendix A.

7. The flight test data were obtained from test instrumentation displayed on the pilot and copilot/gunner panels and recorded on magnetic tape. A detailed listing of the test instrumentation is contained in reference 2, appendix A.

CHRONOLOGY

8. The chronology of the BHC Model 309 attack helicopter evaluation is as follows:

Test directive received	7	July	1972
Test started	11	July	1972
Test interrupted for move to high-elevation site	13	July	1972
High-altitude test started	22	July	1972
High-altitude test ended	26	July	1972
Simulated engine failure test started	7	August	1972
Test completed	8	August	1972

Table 1. Test Conditions¹

Type of Test	Nominal Gross Weight	External Stores Configuration ³ (1b)	Nominal Density Altitude (ft)	Nominal Airspeed (KTAS)
Hover Performance ⁴	11,160	11,560 to 13,370	8500	Zero
	--	12,740	1470	Zero to 54 right Zero to 63 left
Sideward flight	--	12,830	9080	Zero to 40 right Zero to 54 left
	--	12,680	1810	Zero to 45 right Zero to 60 left
Lateral flight performance and agility			12,910	9280
Simulated Failure ⁵	--	13,850	5050	110 to 155

¹Rotor speed: 311 rpm (also 290 and 300 rpm for hover performance), SCAS ON, ECU OFF.

²Clean (no external stores) center-of-gravity location: FS 197 (fwd).

³External stores (two XM159C rocket pods on each wing; maximum rocket loading: 19 inboard each pod; 12 outboard each pod; center-of-gravity location: FS 197 (fwd)).

⁴In ground effect (10-foot skid height), out of ground effect (100-foot skid height).

⁵Simulated engine failures conducted at center-of-gravity location: FS 198.8 (aft).

RESULTS AND DISCUSSION

GENERAL

9. A limited evaluation of the performance and handling qualities of the Bell Helicopter Company Model 309 helicopter was performed at low- and high-altitude sites in the clean and external stores configurations. Except as specifically noted in this report, the performance and handling qualities were essentially unchanged from those reported during previous low-altitude testing. The previously reported deficiency caused by a tail rotor horsepower limitation of 350 shaft horsepower was eliminated by contractor uprating of the drive system to 450 shaft horsepower. The increase in sideward flight airspeeds to 60 knots in left sideward flight and 50 knots in right sideward flight at low altitude, and 50 to 40 knots in left and right sideward flight at high altitude, enhances the ability to hover in high winds. The standard day out-of-ground effect hover ceilings at the TOW mission gross weight of 12,385 pounds and the maximum gross weight of 14,000 pounds are 14,340 feet and 9950 feet, respectively. The hot-day (95°F) hover ceilings out of ground effect for the TOW and maximum gross weights are 7570 feet and 4300 feet. Lateral acceleration performance was limited by engine torque in left lateral flight to 0.33g and 0.24g at the low- and high-elevation sites, respectively. Right lateral accelerations were limited by directional control to 0.28g and 0.14g at the respective low- and high-elevation sites. The helicopter response characteristics following simulated engine failures were significantly milder than those of the standard AH-1G and are satisfactory. The excessive pilot workload during lateral acceleration and reversals is a shortcoming, correction of which is desirable.

Hover Performance

10. The hover performance tests were conducted at skid heights of 10 feet in ground effect (IGE) and 100 feet out of ground effect (OGE). The free-flight hover method was utilized. A measured weighted line, attached to the front of the right skid, was used to establish skid height above the ground. The test conditions are presented in table 1. A summary hover capability comparison is presented in figure 1, appendix C, and is based upon data obtained during this test and the previous low-elevation test (ref 2, app A). The aircraft nondimensional hover performance data are presented in figures 2 and 3, appendix C. Nondimensional tail rotor performance is presented in figures 4 through 7. Maximum engine shaft horsepower available is presented in figure 8. A summary of hover performance is shown in table 2.

Table 2. Hover Performance Summary.¹

Configuration	Hover Ceiling (ft)			
	Standard Day		Hot Day (95°F)	
	In Ground Effect ²	Out of Ground Effect	In Ground Effect ²	Out of Ground Effect
TOW ³	⁴ 16,200	⁴ 14,340	9,300	7,570
External stores ⁵	⁴ 12,520	9,950	6,060	4,300

¹Rotor speed: 311 rpm.

²Skid height: 10 feet.

³Weight: 12,385 pounds.

⁴Extrapolated data.

⁵Maximum gross weight: 14,000 pounds.

11. The previously reported OGE ceiling at the maximum allowable gross weight of 14,000 pounds on a standard day was 11,850 feet and on a 95°F day was 5000 feet, and the standard-day OGE hover ceiling at the TOW mission gross weight of 12,385 pounds was 15,600 feet (para 11, ref 2, app A). This originally reported information was based on extrapolated data from low-altitude testing. The information presented in table 2 was obtained during the high-elevation testing and precluded the requirement to extrapolate below 10,000 feet.

Lateral Acceleration Performance

12. The lateral acceleration performance was evaluated by conducting lateral accelerations and decelerations IGE (skid height, approximately 40 feet) in the external stores configuration at density altitudes of 1810 feet (low-elevation site) and 9280 feet (high-elevation site). A change in the tail rotor drive system rating from 350 shp to 450 shp permitted a more thorough evaluation of right lateral accelerations than was accomplished in previous testing (ref 2, app A). In addition, the sideward airspeed envelope was expanded to 60 knots and 50 knots left and right sideward airspeed, respectively, at low altitude, and 50 and 40 knots, left and right, at high altitude. Acceleration was accomplished by rolling the aircraft to a predetermined bank angle with a rapid lateral control motion while adding power to maintain constant altitude, and attempting to maintain constant attitude and heading. Lateral performance data, shown in figures 9

and 10, appendix E, were recorded with a ground-positioned grid camera. Figures 11 through 14 show typical time histories of lateral acceleration. A ground pace vehicle was used to determine limit sideward speed. The results of these tests are summarized in table 3.

13. At the low-elevation site (field elevation 630 feet), the maximum bank angle for left lateral acceleration was 25 degrees, as limited by the transmission torque limit. The corresponding acceleration to 30 knots true airspeed (KTAS) was 0.33g. It was necessary to closely monitor engine torque to preclude an over-torque condition. Right sideward accelerations could be accomplished to a maximum of 17.7 degrees bank angle with a corresponding acceleration of 0.28g. Right lateral accelerations were limited by available directional control to approximately 45 KTAS. As a result of the change in tail rotor horsepower limitation and the increase in the sideward airspeed envelope, higher airspeeds were attained during lateral accelerations, and a slightly higher right lateral acceleration was obtained.

14. At the high-elevation site (field elevation 7535 feet), the maximum left sideward acceleration was 0.24g with a bank angle of approximately 16 degrees, and was limited by the transmission torque limit. Engine torque and rotor speed were more difficult to control precisely at the higher density altitude. Directional control limited right lateral acceleration to approximately 0.14g, at a roll attitude of 8 degrees.

HANDLING QUALITIES

Takeoff and Landing Characteristics

15. Takeoff and landing characteristics were qualitatively evaluated throughout this test with the stability and control augmentation system (SCAS) ON at gross weights from 11,000 to 13,500 pounds at a forward center of gravity (cg). Surface winds varied from calm to gusts of 10 knots.

16. Takeoffs and landings were made with a nearly constant level attitude at the lower density altitude (ref 2, app A). At the high-elevation site with forward cg loading, aircraft attitude was approximately one degree nose-low and two degrees left-wing-low. The small change from the ground attitude to the hover attitude was not objectionable.

Sideward Flight Characteristics

17. Sideward flight tests were conducted to determine control margins and handling qualities while hovering in winds. Sideward flight

Table 3. Maximum Lateral Flight Performance.

Roll Angle (deg)	Acceleration to 30 KTAS (g)	Airspeed (kt)	Time ¹ (sec)	Distance ² (ft)
25.0 left ³	0.33	10	1.5	15
		20	3.1	35
		30	4.6	70
		40	6.2	145
		50	8.4	280
		60	12.9	630
17.7 right ³	0.28	10	1.6	32
		20	3.4	97
		30	5.6	215
		35	6.8	295
		40	8.4	420
		44	10.3	590
16.0 left ⁴	0.24	10	1.8	18
		20	3.8	70
		30	6.5	185
		40	9.9	385
		45	13.1	545
		50	14.9	720
8.0 right ⁴	0.14	10	2.4	28
		20	5.6	105
		30	10.9	340
		35	15.3	580
		40	20.7	945

¹Time measured from start of lateral motion.²Approximate.³Configuration: external stores, average gross weight: 12,680 pounds.
Center-of-gravity location: 196.6 in.

Density altitude: 1810 feet.

Outside air temperature: 23.5°C.

⁴Configuration: external stores, average gross weight: 12,910 pounds.

Center-of-gravity location: 196.8 in.

Density altitude: 9280 feet.

airspeeds were determined using a calibrated ground pace vehicle. The helicopter was in the external stores configuration at a forward cg and was flown at an approximate skid height of 15 feet at the conditions shown in table 1. The tail rotor blade angle limits were changed from 17.4 degrees, left, to 19.0 degrees, left, with a corresponding right setting of 10.5 degrees. The rigging was further changed to provide blade angles of 21.0 degrees, left, and 8.5 degrees, right, for high-elevation testing.

18. Increased shaft horsepower limits for the tail rotor drive system permitted increase of the sideward airspeed envelope reported in reference 2, appendix A, from 30 knots in right sideward flight to 50 knots at low altitude and 40 knots at the high-elevation site. In addition, left sideward airspeed limits were increased to 60 knots at low altitude and 50 knots at high altitude. Sideward flight test results are presented in figures 15 and 16, appendix C. The variation of lateral control position with sideward airspeed was essentially neutral. The directional control position variation was essentially linear with airspeed, except for an abrupt discontinuity between 15 and 20 KTAS in left sideward flight as reported in reference 2, appendix A. This discontinuity was noticeable but not objectionable. Minimal pilot compensation was required to maintain heading during left and right sideward flight (HQRS 3). Adequate control margins remained in left and right sideward flight at 35 KTAS to compensate for minor gust disturbances. The increased sideward flight capability enhances the ability to hover in high wind.

19. The original evaluation of the Model 309 revealed a tail rotor power limitation which restricted operation within the normal flight envelope (para 34, ref 2, app A). This was a deficiency in that directional control could not be maintained within the tail rotor drive system limitation while hovering in gusty winds. The tail rotor power limit was subsequently increased to 450 shp from the original 350 shp (ref 7). During the conduct of this evaluation, no difficulty was encountered in maintaining directional control or correcting for large and rapid yaw excursions within the flight envelope and the allowable tail rotor drive system power limit. The previously reported deficiency no longer exists.

Lateral Acceleration Handling Qualities

20. The lateral acceleration handling qualities were evaluated during lateral performance testing at the conditions shown in table 1. Representative time histories of lateral accelerations are presented in figures 11 through 14, appendix C. The expanded tail rotor horsepower rating permitted full use of the left directional control for right lateral flight. Rapid deceleration from maximum lateral airspeeds required considerable pilot compensation due to torque transients

resulting from high roll rates and large directional control inputs required for directional control (HQRS 3). Maximum performance requires operation at the torque limits. Rapid decelerations (reversals) from maximum lateral airspeeds required considerable pilot compensation due to rapid torque changes required to maintain constant altitude (HQRS 5).

Simulated Engine Failure Characteristics

21. The response of the helicopter following a sudden engine failure was evaluated in level flight from 110 knots indicated airspeed (KIAS) to the airspeed at maximum rated power in the external stores configuration at maximum gross weight. Engine failure was simulated by rapidly rolling the throttle control to the idle position. Flight controls were held fixed until the minimum transient rotor speed (260 rpm) was approached. Representative time histories of aircraft response and recovery are shown in figures 17 and 18, appendix C. Figure 19 presents a summary of tail rotor drive system transient loads during the simulated power failure. A summary of aircraft response is presented in table 4.

Table 4. Aircraft Response Following Simulated Engine Failures.¹,

Entry Airspeed (KCAS)	Maximum Roll Rate (deg/sec)	Roll Rate At Recovery (deg/sec)	Maximum Yaw Rate (deg/sec)	Yaw Rate At Recovery (deg/sec)	Rotor Speed Decay Rate (rpm/sec)
135	6.5 left	6.5	7.5 left	5	29
139	8.0 left	6.0	8.0 left	zero	29
142	16.0 left	8.0	10.0 left	5	31
147	18.0 left	8.0	10.0 left	7	36
155	21.5 left	12.5	10.0 left	4	44

¹Average gross weight: 13,880 pounds.

Average center-of-gravity: 198.8 inches.

Average density altitude: 4810 feet.

Average outside air temperature: 26.6 °C.

Average thrust coefficient: 0.006095

Average rotor speed: 311 rpm.

Configuration: external stores (4 XM159C rocket pods).

22. Aircraft responses following the simulated sudden engine failures were relatively mild except for rapid rotor speed decay at high

power settings and an abrupt yaw to the left. Rotor speed decay increased with increasing entry airspeed from 29 rpm per second at 135 knots calibrated airspeed (KCAS) to 44 rpm per second at 155 KCAS. This rapid decay permitted a delay of only 0.8 second from power loss at maximum power to reductions of collective pitch. The 2-second delay requirement of paragraph 3.5.5 of the military specification, MIL-H-8501A, could not be attained. The abrupt yaw following power loss provided an immediate cue which was detectable before rotor speed had approached the minimum transient rpm. In ball-centered powered flight, the helicopter is in a small right sideslip of approximately 3 degrees at 150 KIAS. The abrupt left yaw following a power loss results in an additional transient sideslip of approximately 9 degrees. The sideslip angle generated by the yaw at the high power settings exceeded the sideslip limit of the safety-of-flight release (7 degrees) but caused no handling qualities difficulties.

23. Recovery from simulated sudden engine failure at high entry power settings was initiated by a large, rapid reduction of collective pitch to arrest rotor speed decay. The roll rate caused by the sudden power loss increased following reduction of collective pitch. A large lateral control displacement was required to control roll attitude. Longitudinal and directional control inputs were relatively small in establishing a steady-state autorotation. Reduction of collective pitch was very effective in stopping rotor speed decay and rotor speed was quickly regained without longitudinal cyclic application. The helicopter response characteristics following sudden power loss observed during this test were easily controllable with minimal pilot compensation and are significantly milder than the response characteristics of the AH-1G following a power loss (HQRS 3).

CONCLUSIONS

GENERAL

24. The following conclusions were reached upon completion of testing:
- a. The increased sideward flight capability enhances the ability to hover in high winds (para 18).
 - b. The previously reported deficiency, inability to correct for rapid and large yaw excursions within the allowable tail rotor horsepower limit, no longer exists (para 19).
 - c. The helicopter response characteristics following simulated engine failures were significantly milder than those of the standard AH-1G and are satisfactory.
 - d. One handling qualities shortcoming was observed during this test. Except for this shortcoming, the handling qualities observed during this evaluation were essentially the same as those observed during previous testing.

Shortcoming Affecting Mission Accomplishment

25. Correction of the following shortcoming is desirable: excessive pilot effort required during lateral accelerations and reversals (para 20).

Specification Conformance

26. Within the scope of this test, the Model 309 helicopter failed to meet the requirement of paragraph 3.5.5 of MIL-H-8501A, in that a rapid rotor rpm loss did not permit the attainment of the 2-second delay from power loss to reduction in collective pitch following a simulated engine failure.

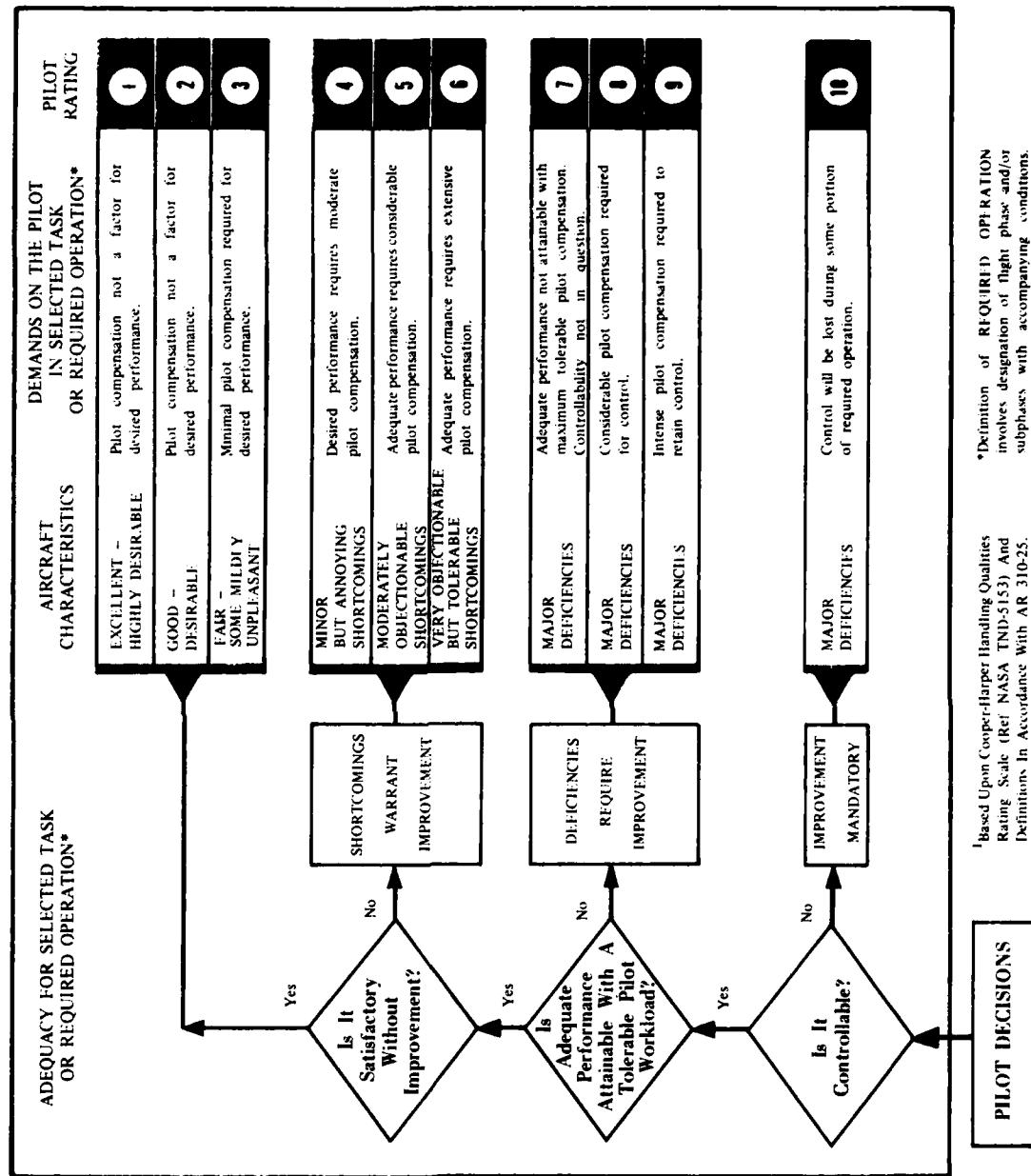
RECOMMENDATION

27. The shortcoming, correction of which is desirable, should be corrected (para 25).

APPENDIX A. REFERENCES

1. Letter, AVSCOM, AMSAV-EF, 9 March 1972, subject: Attack Helicopter Evaluation of the Model 309 Helicopter, Project No. 72-10.
2. Final Report, USAASTA, Project No. 72-10, *Attack Helicopter Evaluation, Model 309 KingCobra Helicopter*, July 1972.
3. Letter, AVSCOM, AMSAV-EF, 20 July 1972, subject: BHC Model 309 High Elevation Test, Project No. 72-31.
4. Message, AVSCOM, AMSAV-EF, 08-07, Unclassified, 7 August 1972, subject: BHC Model 309 Autorotation Evaluation, Project No. 72-34.
5. Checklist, Bell Helicopter Company, "Model 309 Pilot's Checklist" (undated).
6. Letter, AVSCOM, AMSAV-EF, 2 June 1972, subject: Safety-of-Flight Release for the Bell Model 309 KingCobra Flight Evaluation.
7. Message, AVSCOM, AMSAV-EF, 06-13, Unclassified, 22 June 1972, subject: Attack Helicopter Requirements Evaluation.
8. Message, AVSCOM, AMSAV-EF, 07-05, Unclassified, 5 July 1972, subject: Safety-of-Flight Release for the Bell Model 309 KingCobra.
9. Message, AVSCOM, AMSAV-EF, 07-08, Unclassified, 11 July 1972, subject: Safety-of-Flight Release for the Bell Model 309 KingCobra.
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11. Message, AVSCOM, AMSAV-EF, 08-08, Unclassified, 7 August 1972, subject: Safety-of-Flight Release for the Bell Model 309 KingCobra Flight Evaluation.
12. Flight Test Manual, Naval Air Test Center, FTM No. 102, *Helicopter Performance*, 28 June 1968.
13. Flight Test Manual, Naval Air Test Center, FTM No. 101, *Helicopter Stability and Control*, 10 June 1968.

APPENDIX B. HANDLING QUALITIES RATING SCALE



*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions.

Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref: NASA TN-D-5153). And Definitions In Accordance With AR 31025.

APPENDIX C. TEST DATA

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Hover Comparison	1
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Sideward Flight (Agility Tests)	11 through 14
Control Positions	15 and 16
Autorotational Entries	17 and 18
Throttle Chop Summary	19

FIGURE NO. 1
 SUMMARY HOVER CAPABILITY COMPARISON
 BELL MODEL 309, USA S/N NA
 LYCOMING ENGINE MODEL T55-L7C S/N E452(E)

MAXIMUM POWER

NOTES: 1) CURVES DERIVED FROM FIGS 2, 3, AND 8

2) ROTOR SPEED = 311 RPM

3) WINDS LESS THAN 3 KTS

4) TRANSMISSION LIMIT BASED ON 2050 SHP

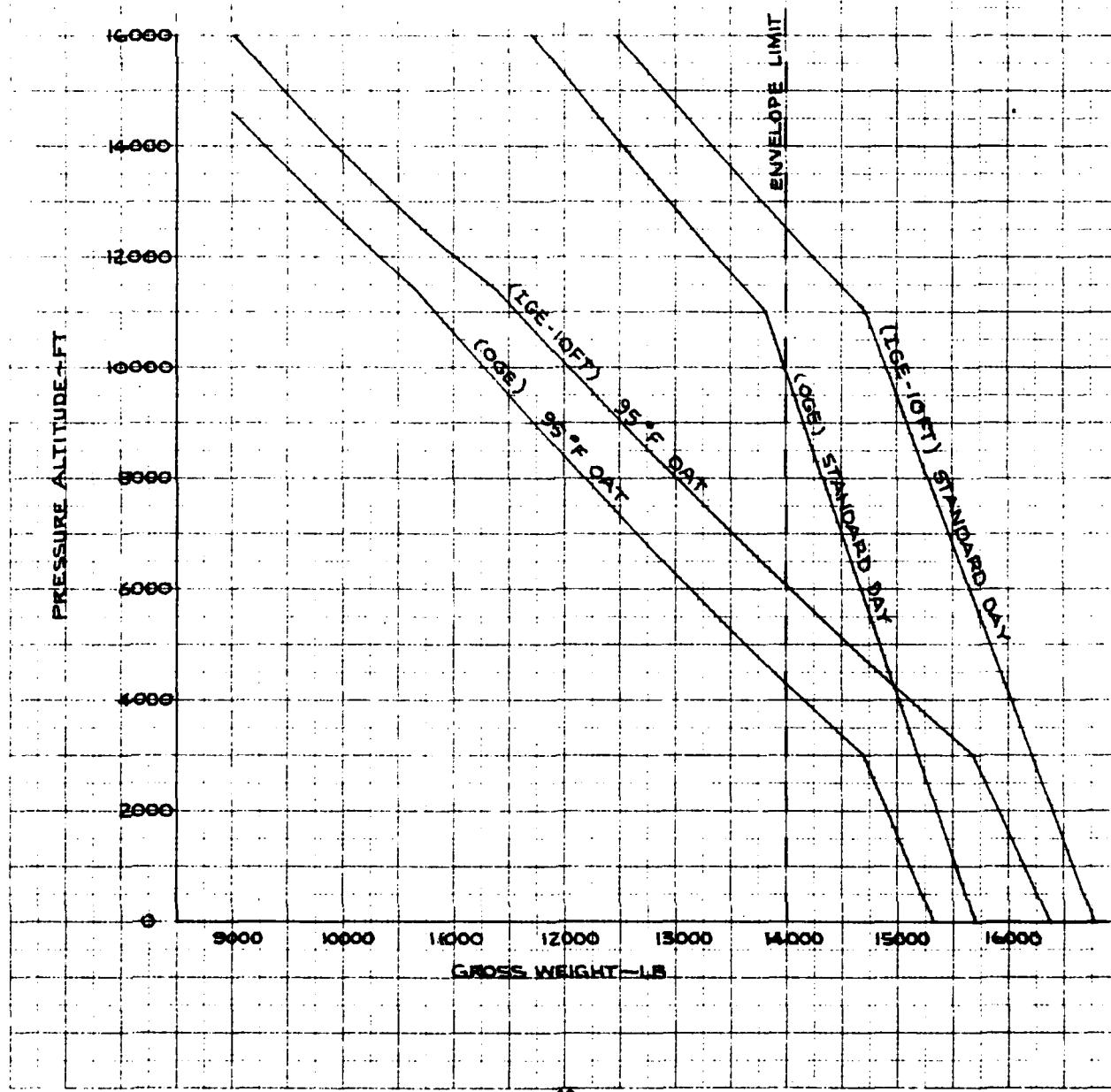


FIGURE NO. 2
 NON-DIMENSIONAL HOVERING PERFORMANCE
 BELL MODEL 309, USA S/N: N/A
 LYCOMING ENGINE MODEL T55-L-7C S/N E-52(E)
 SKID HEIGHT = 10 FEET

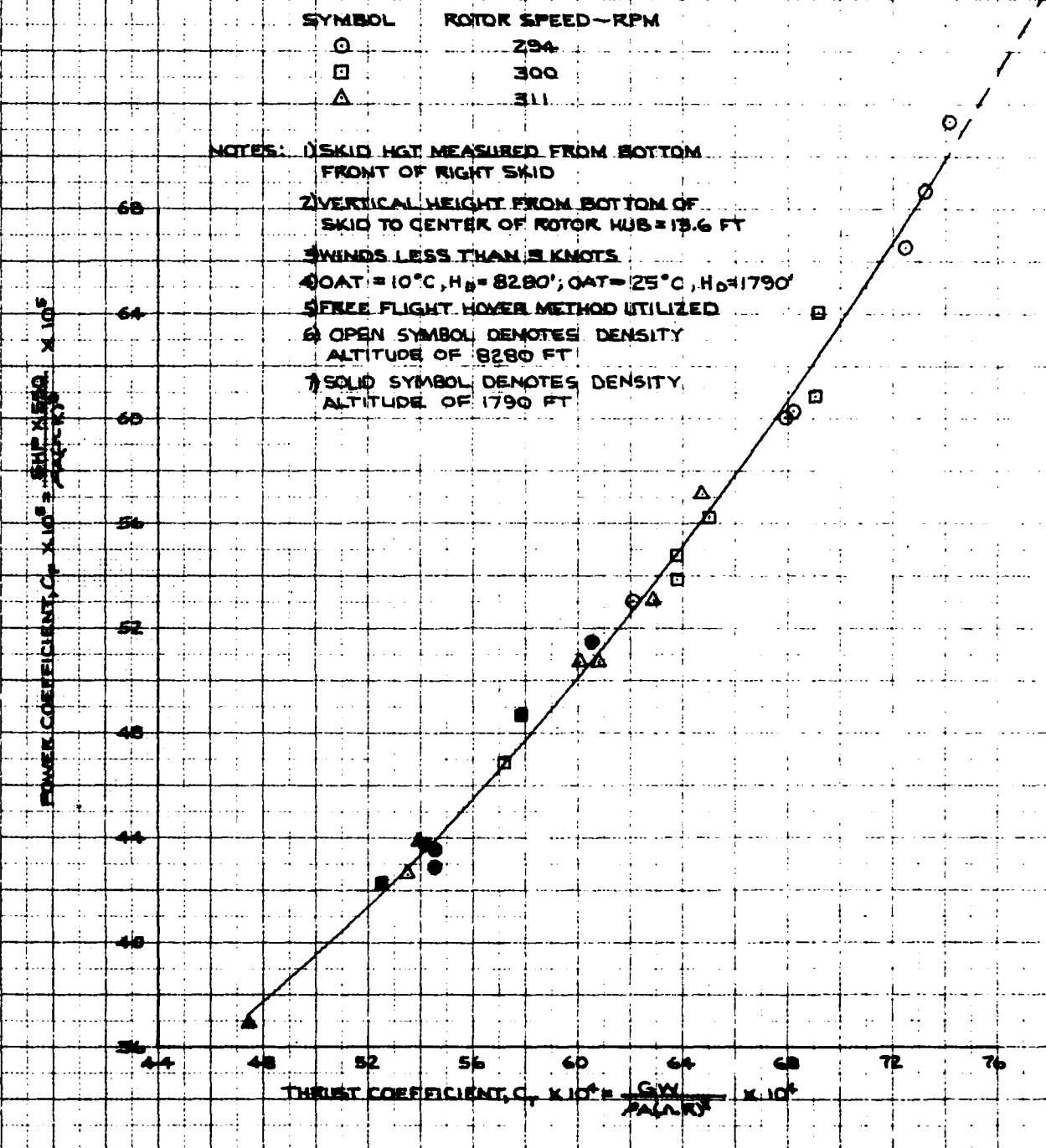


FIGURE NO. 3
 NON-DIMENSIONAL HOVERING PERFORMANCE
 BELL MODEL 309, USA 5% N/A
 LYCOMING ENGINE MODEL T55-L-7C S/N E-52(F)

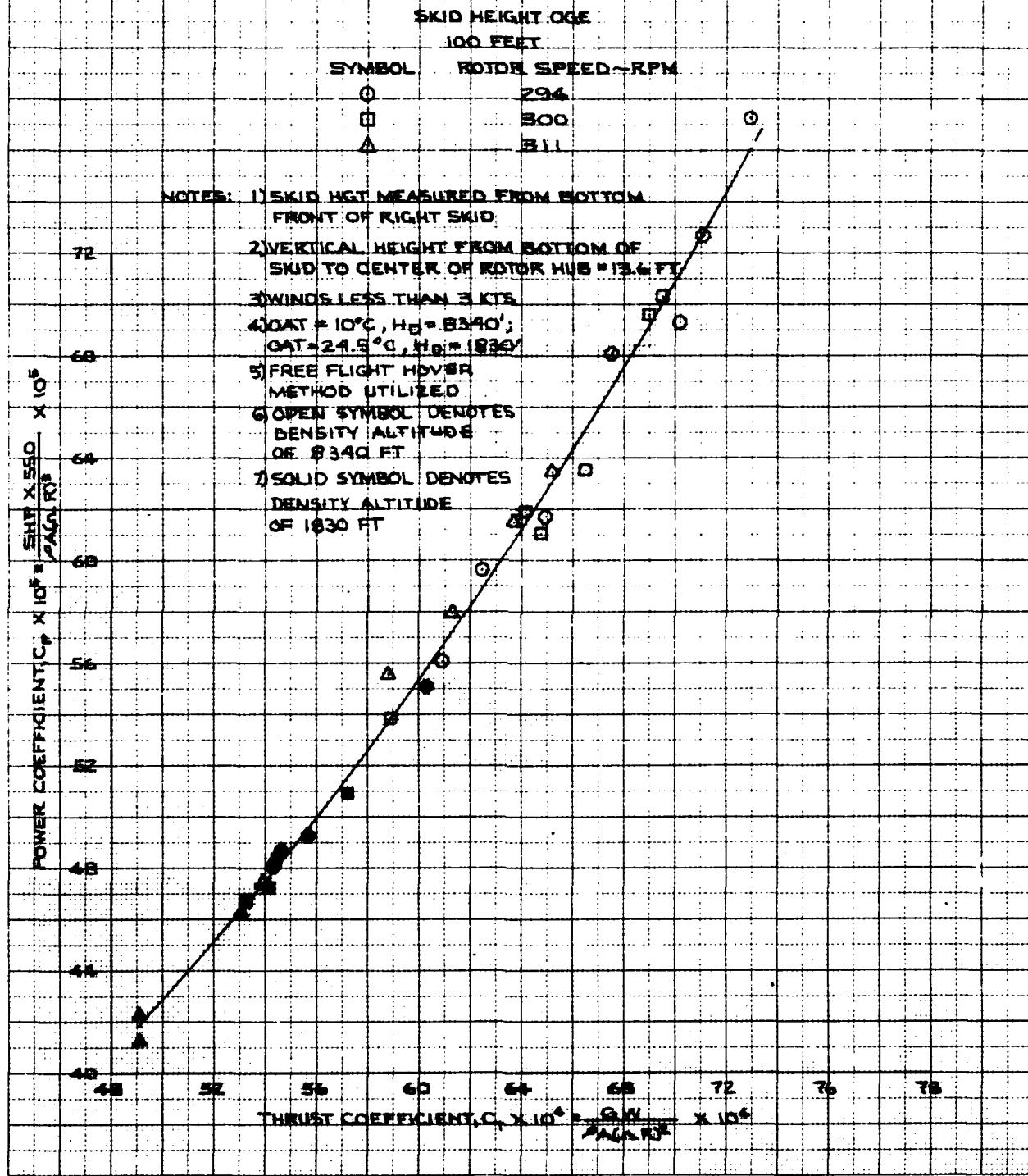


FIGURE NO. 4
NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
BELL MODEL 309, USA S/N NVA
LYCOMING ENGINE MODEL T55-L-7C S/N E52(E)
SKID HEIGHT = 10 FEET

SYMBOL	MAIN ROTOR SPEED - RPM		TAIL ROTOR SPEED - RPM
	294	300	311
○			1527
□			1558
△			1615

NOTES: 1) OPEN SYMBOL DENOTES DENSITY ALTITUDE OF 8280 FT
2) SOLID SYMBOL DENOTES DENSITY ALTITUDE OF 1790 FT

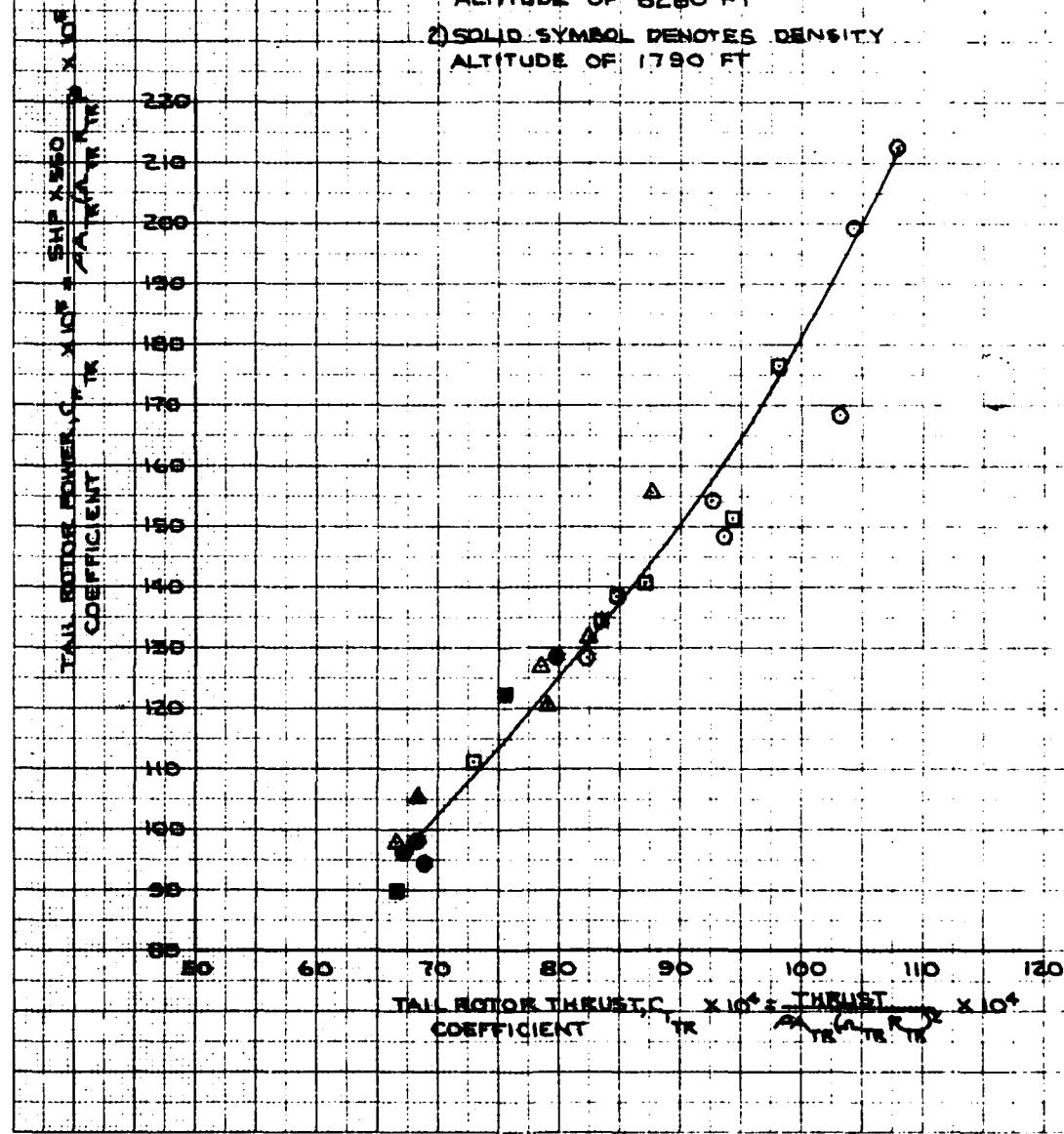


FIGURE NO. 5
 NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
 BELL MODEL 309, USA S/N N/A
 LYCOMING ENGINE MODEL T55-LTC S/N E52(E)
 SKID HEIGHT OGE
 100 FEET

SYMBOL	MAIN ROTOR SPEED - RPM	TAIL ROTOR SPEED - RPM
○	294	1527
□	300	1558
△	311	1615

NOTES: 1) OPEN SYMBOL DENOTES DENSITY
 ALTITUDE OF 6340 FT
 2) SOLID SYMBOL DENOTES DENSITY
 ALTITUDE OF 1930 FT

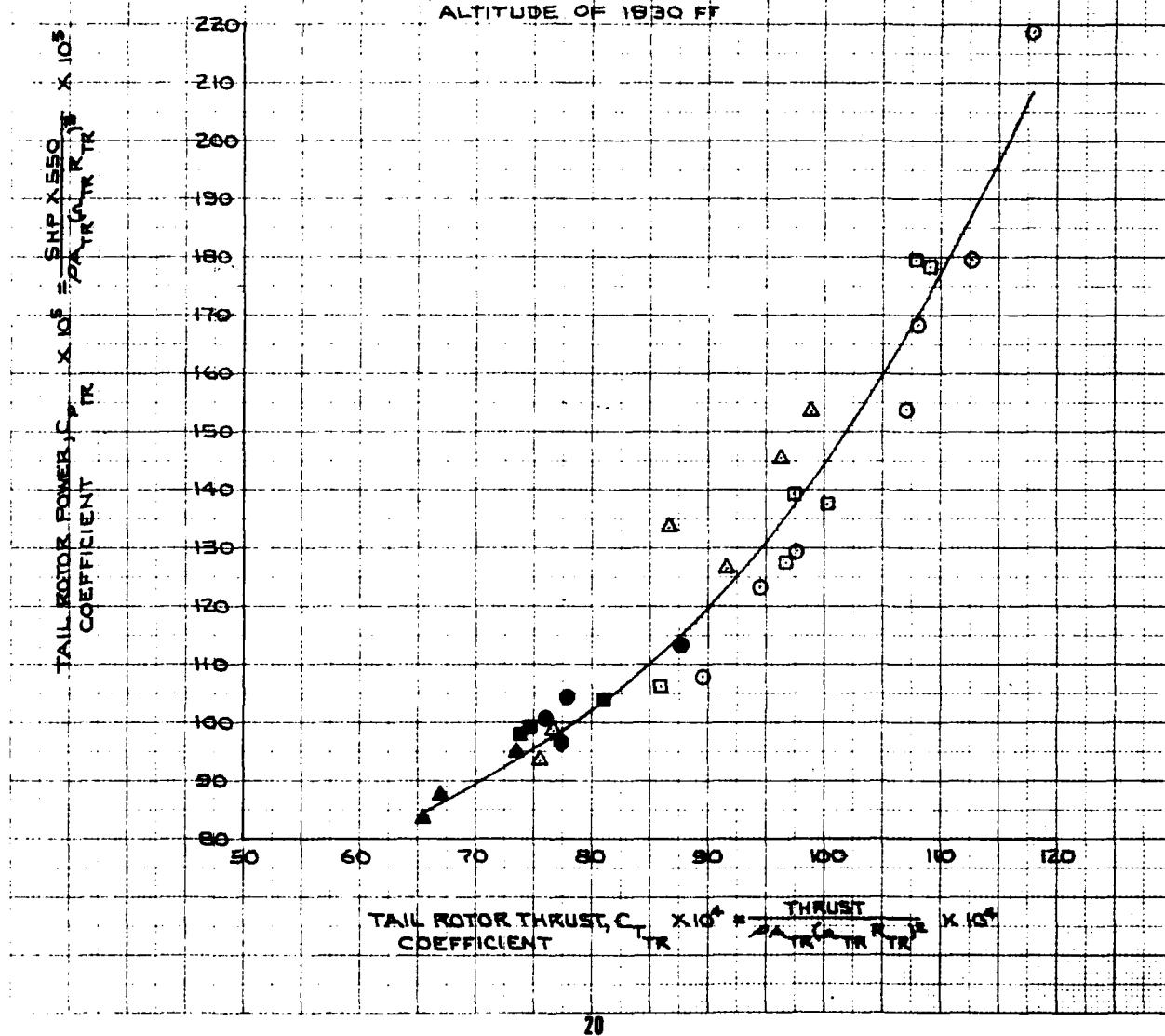
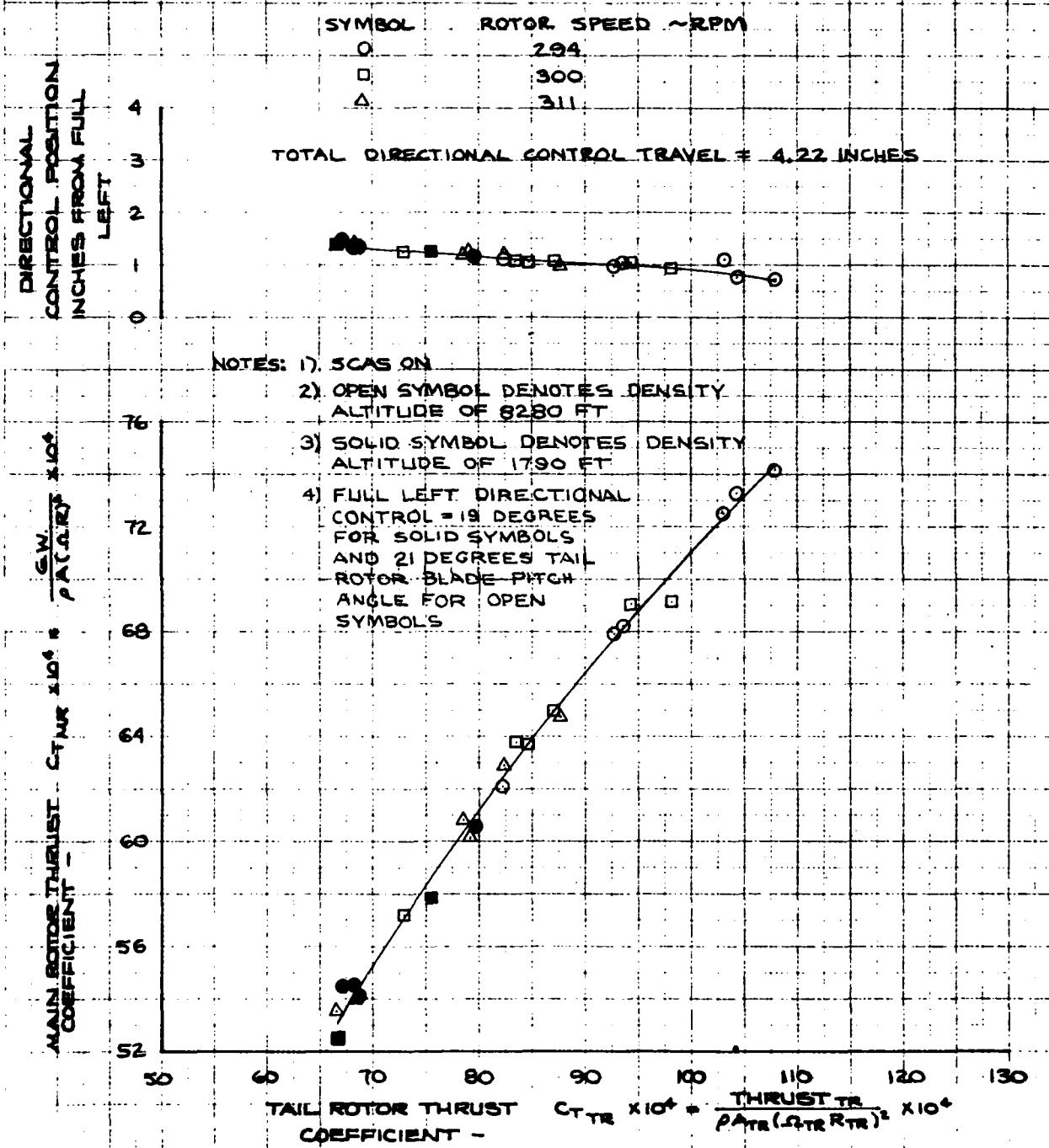


FIGURE NO. 6
 NON-DIMENSIONAL TAIL ROTOR PERFORMANCE
 BELL MODEL 309, USA 5% N/A
 LYCOMING ENGINE MODEL T55-L-7C 5% E-52(E)
 SKID HEIGHT = 10 FEET



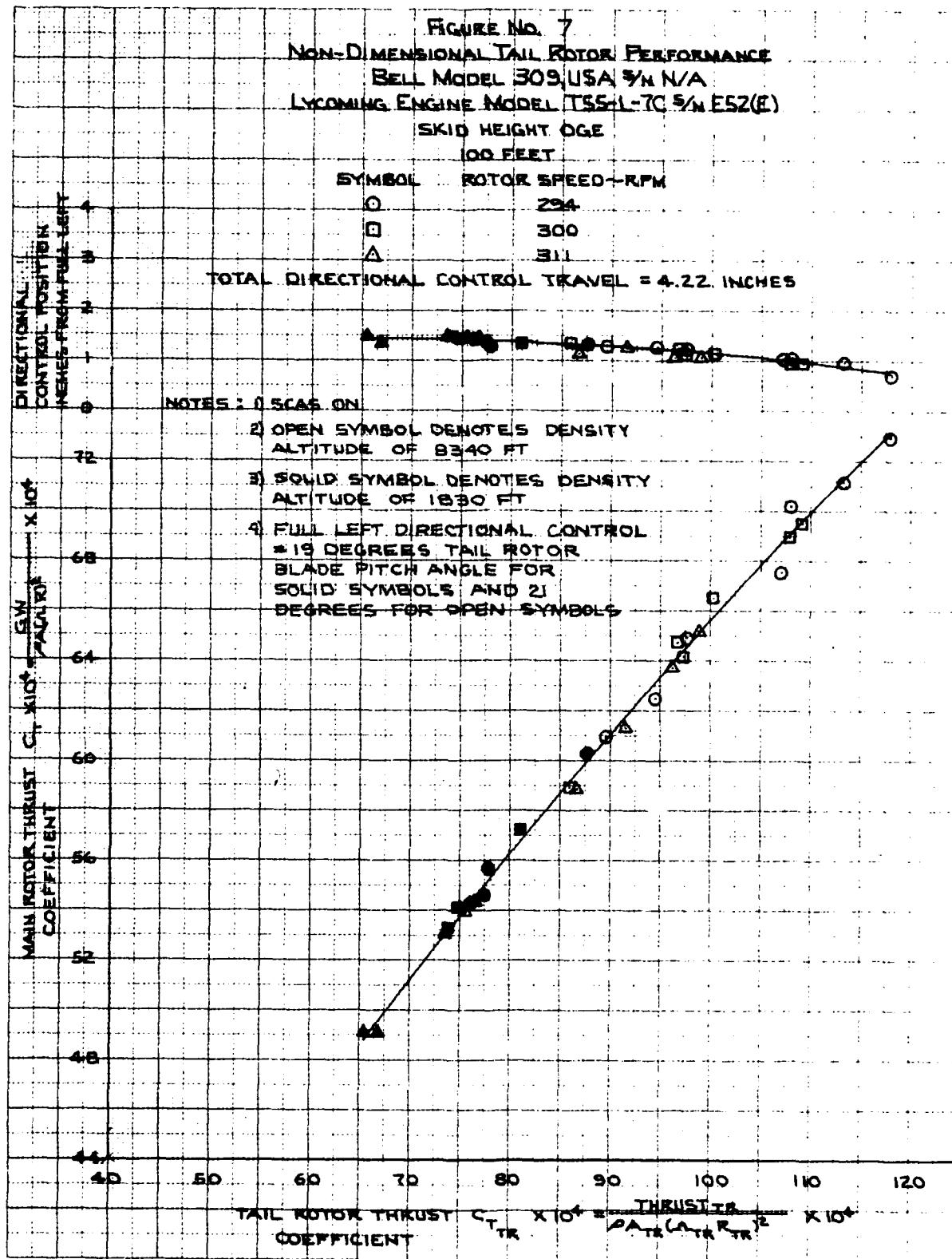


FIGURE NO. 8
 SHAFT HORSEPOWER AVAILABLE
 BELL MODEL 309, USA 5/M N/A
 LYCOMING ENGINE MODEL TSS-L-TC
 PLOT FOR MAXIMUM POWER

NR = 301

- NOTES: 1) 0 AIRSPEED
 2) AIRBLEED 4% (ECU OFF)
 3) ANTI-ICE OFF
 4) COMPRESSOR INLET TEMP RISE 0°C
 5) COMPRESSOR INLET PRESSURE RATIO 9.95
 6) EXHAUST PRESSURE LOSS ± 1.0 IN. H₂O
 7) HP EXTRACTION 5.0
 8) SOURCE OF DATA: LYCOMING ENGINE COMPUTER
 DECK NO. BF 9.00-46.00

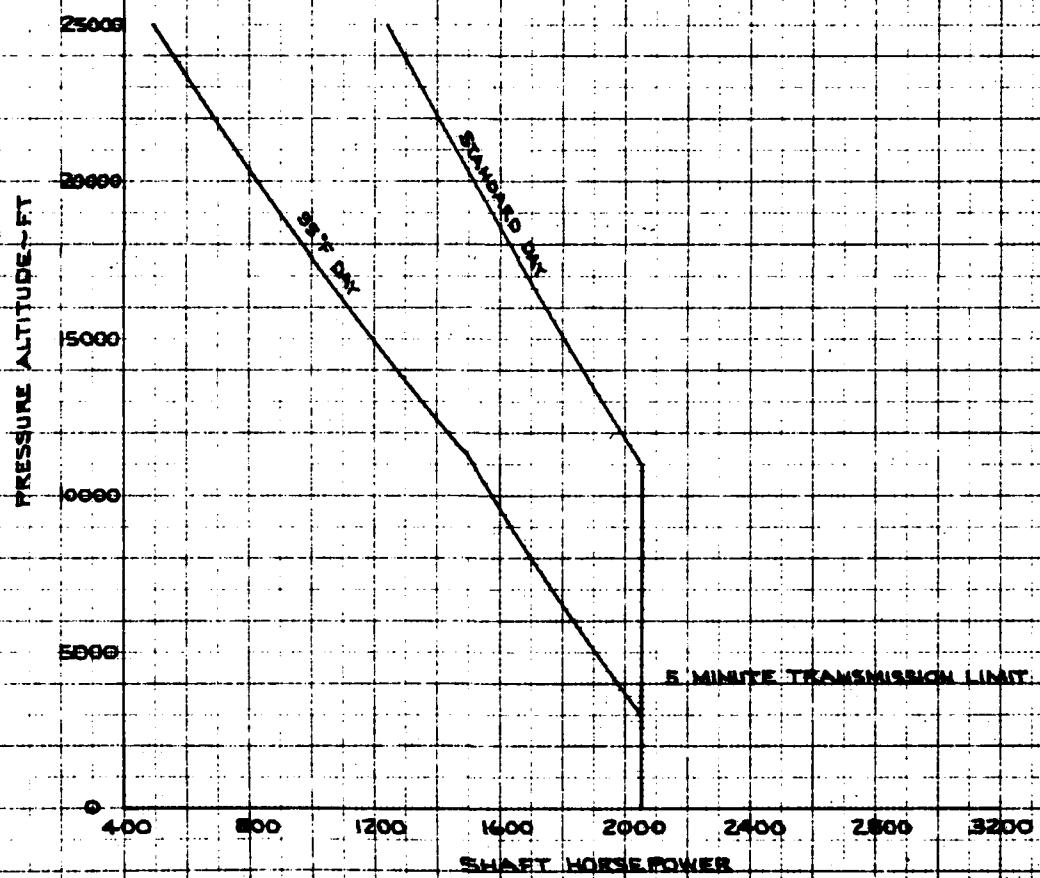


FIGURE NO. 9
AVERAGE LATERAL FLIGHT ACCELERATION
BELL MODEL 309, USA S/N N/A

Avg GROSS WEIGHT	Avg CG LOCATION	Avg DENSITY	Avg OAT	Avg ROTOR SPEED	Avg C _T	CONFIGURATION
-48 2680	-1H. 196.6	-FT 1010	-°C 23.5	-RPM 34	.005087	EXTERNAL STORES (4 XM-159C ROCKET PODS)

NOTE: 1) AVG ACCELERATION TO 30 KTS.

2) FULL LEFT DIRECTIONAL CONTROL = 19 DEGREES
TAIL ROTOR BLADE PITCH ANGLE

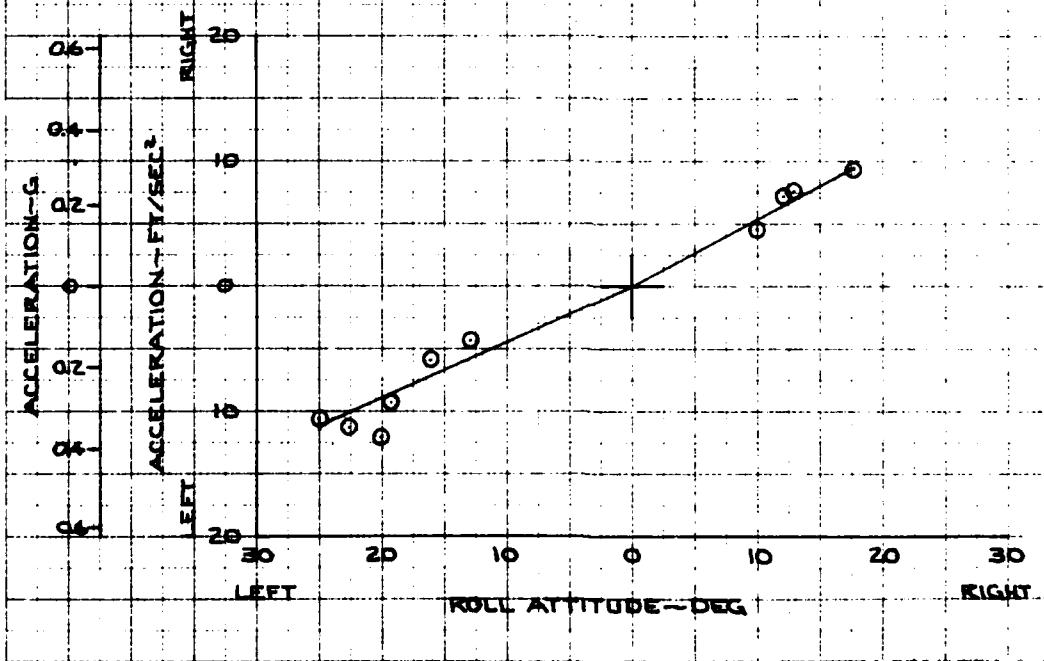


FIGURE NO. 10
AVERAGE LATERAL FLIGHT ACCELERATION
BELL MODEL 309, USA S/N N/A

ANG GROSS WEIGHT -LB	Avg CG LOCATION -IN.	ANG DENSITY ALTITUDE -FT	Avg OAT -°C	Avg ROTOR SPEED -RPM	Avg C _f	CONFIGURATION
2910	156.8	9280	183	311	006503	EXTERNAL STORES (4 XM-153C ROCKET PODS)

- NOTES: 1) AVG ACCELERATION TO 30 KTS
 2) FLAGGED SYMBOL DENOTES LEFT DIRECTIONAL
 REQUIREMENT TO MAINTAIN HEADING
 EXCEEDED AVAILABLE AT 18 KTS
 3) FULL LEFT DIRECTIONAL CONTROL = 21
 DEGREES TRAIL ROTOR BLADE PITCH ANGLE

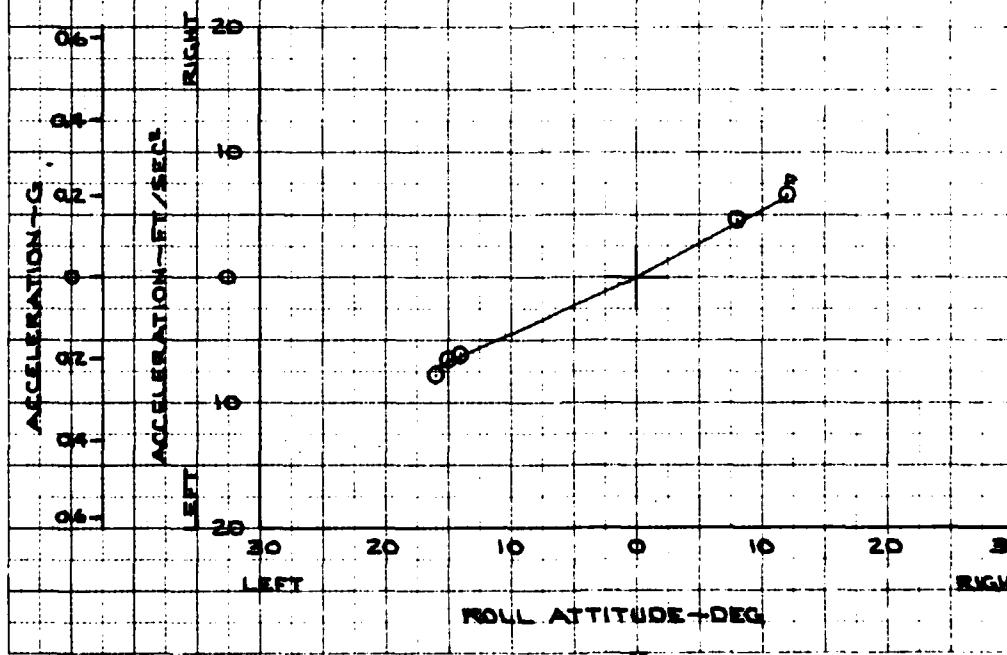


FIGURE No. 11
TIME HISTORY OF LEFT SIDEWARD FLIGHT (AGILITY TEST)

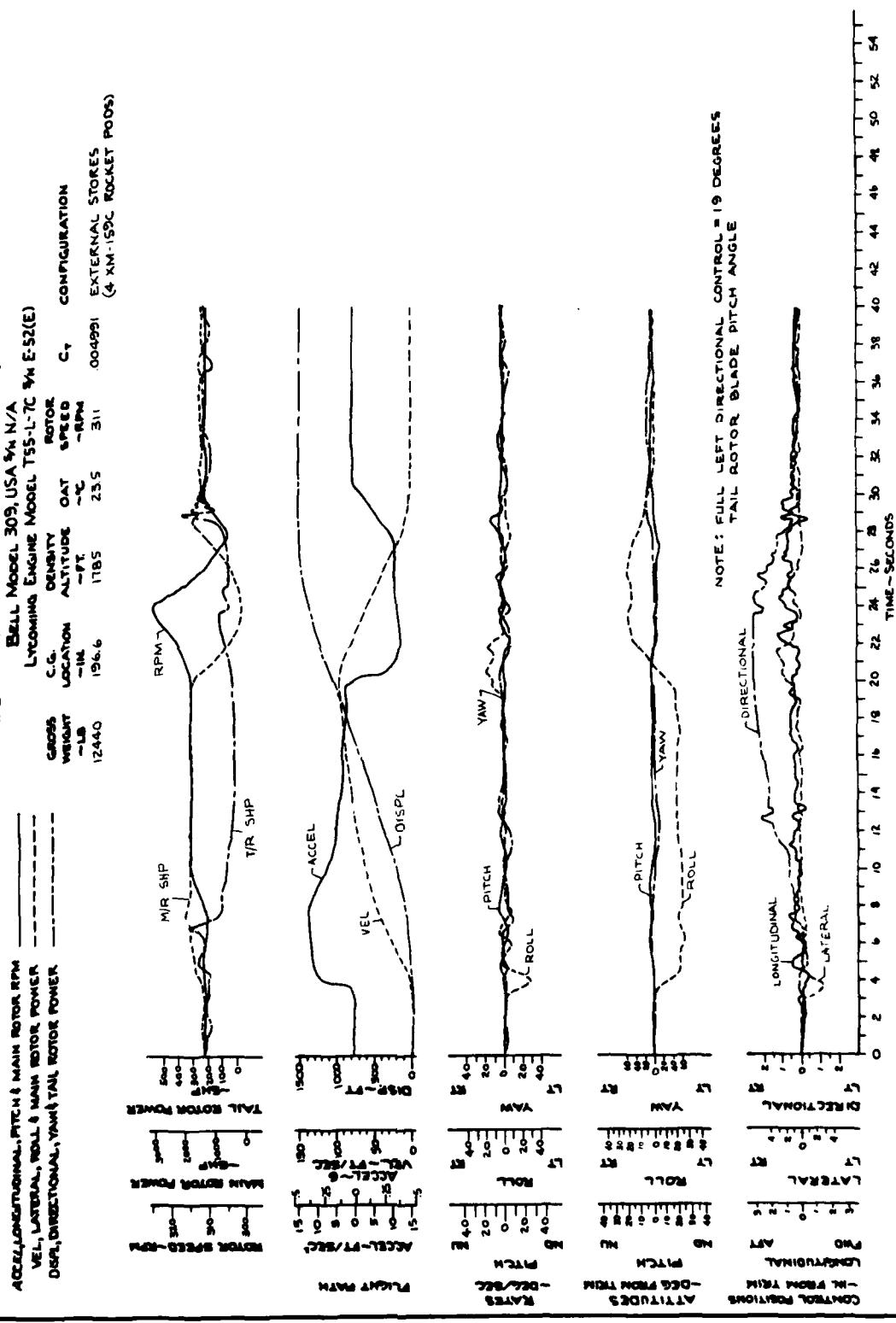


FIGURE NO. 12
TIME HISTORY OF RIGHT SIDEWARD FLIGHT(AGILITY TEST)

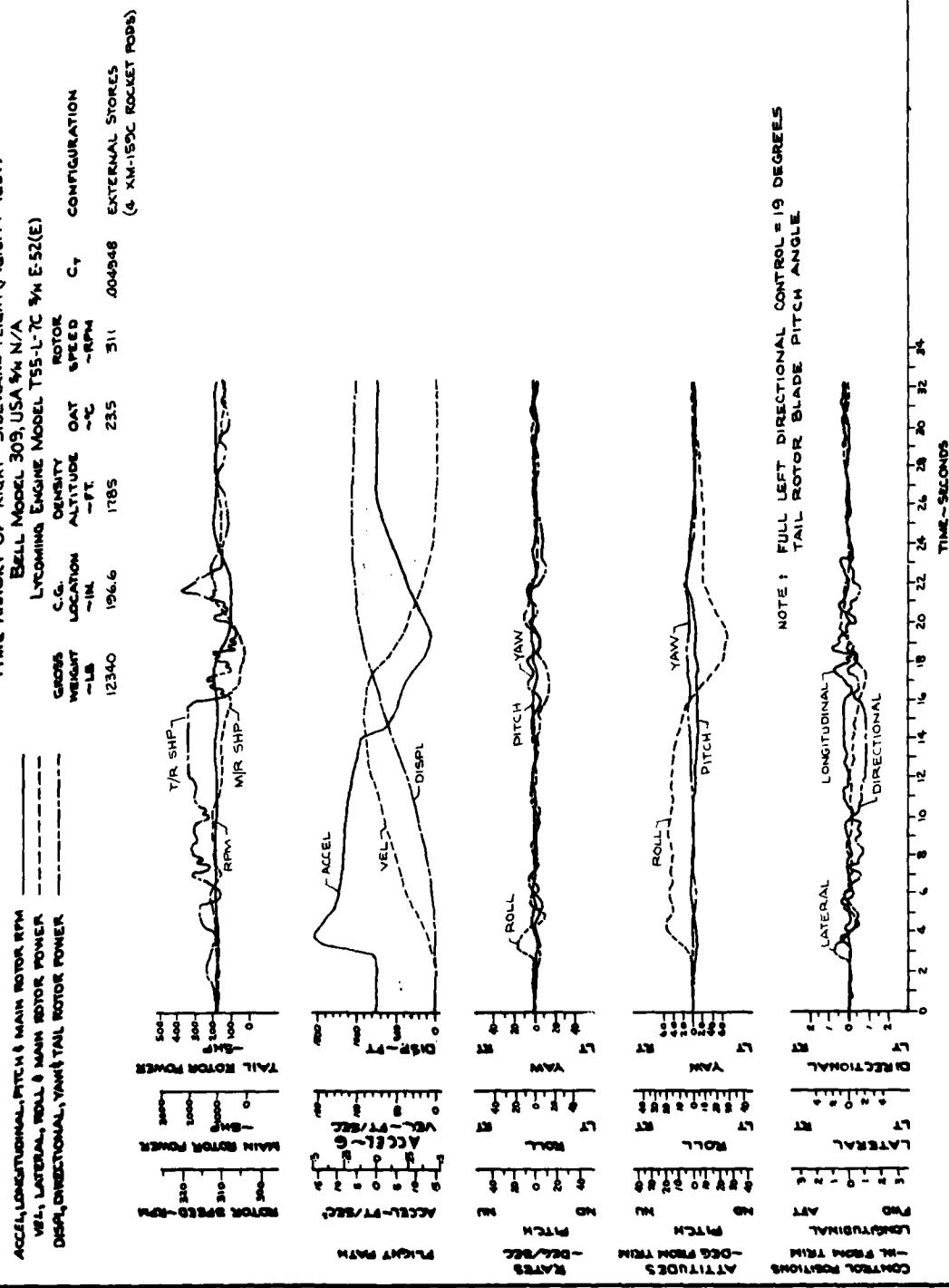


FIGURE NO. 13
TIME HISTORY OF LEFT SIDEWARD FLIGHT (AGILITY TEST)

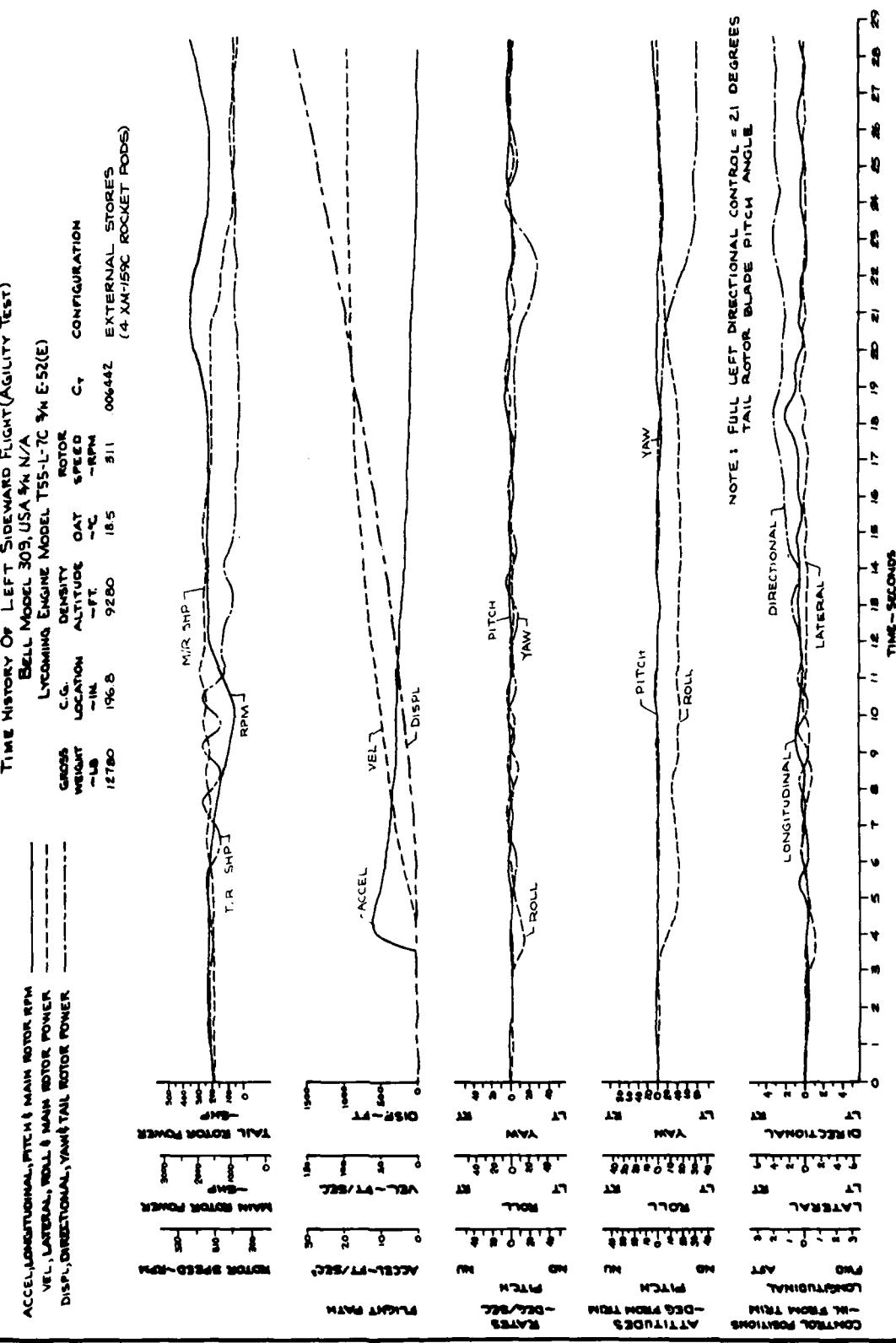


FIGURE NO. 14
TIME HISTORY OF RIGHT SIDEWARD FLIGHT (AGILITY TEST)

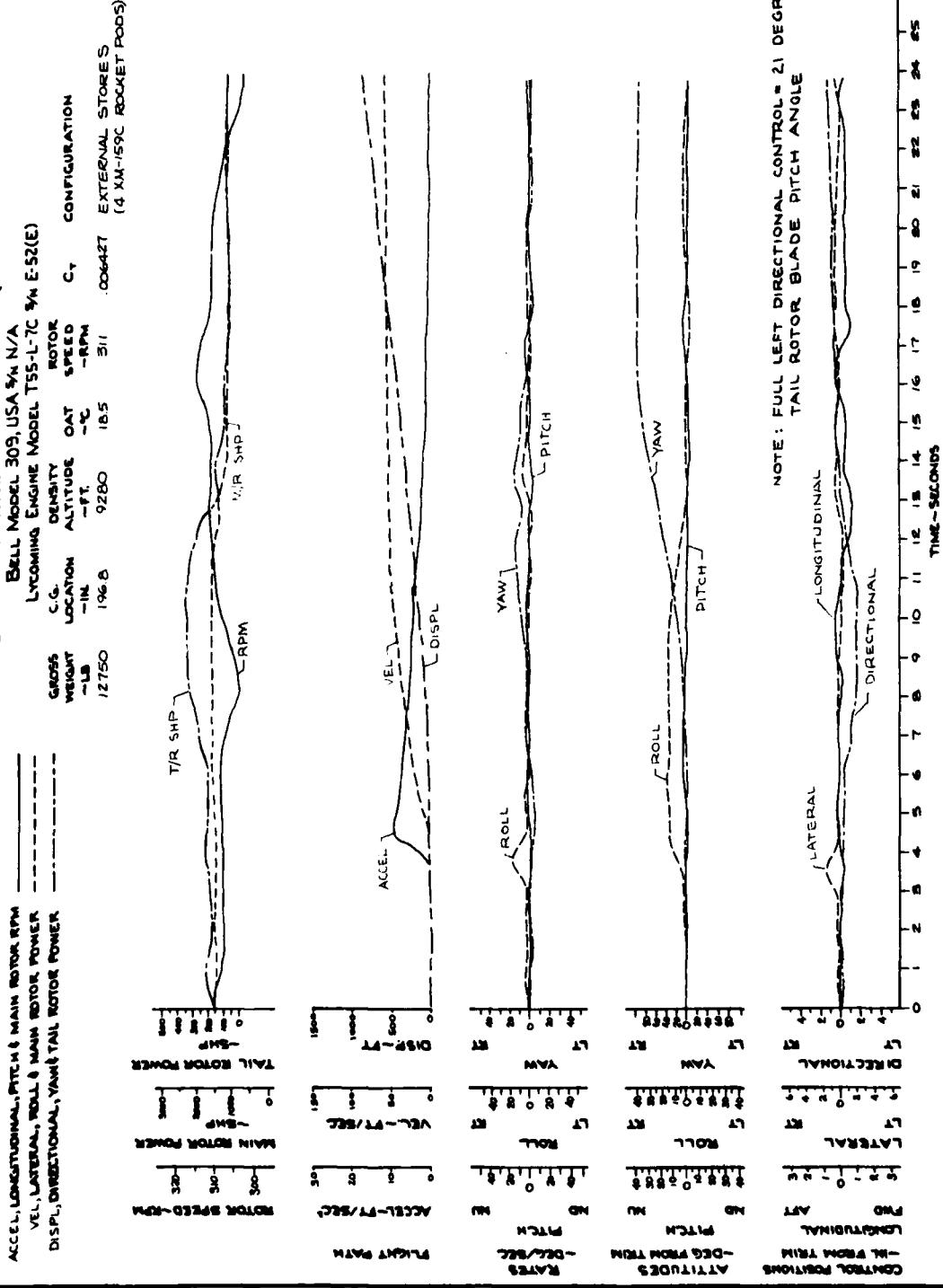


FIGURE NO. 15
CONTROL POSITIONS IN SIDEWARD FLIGHT
BELL MODEL 309, USA S/N N/A

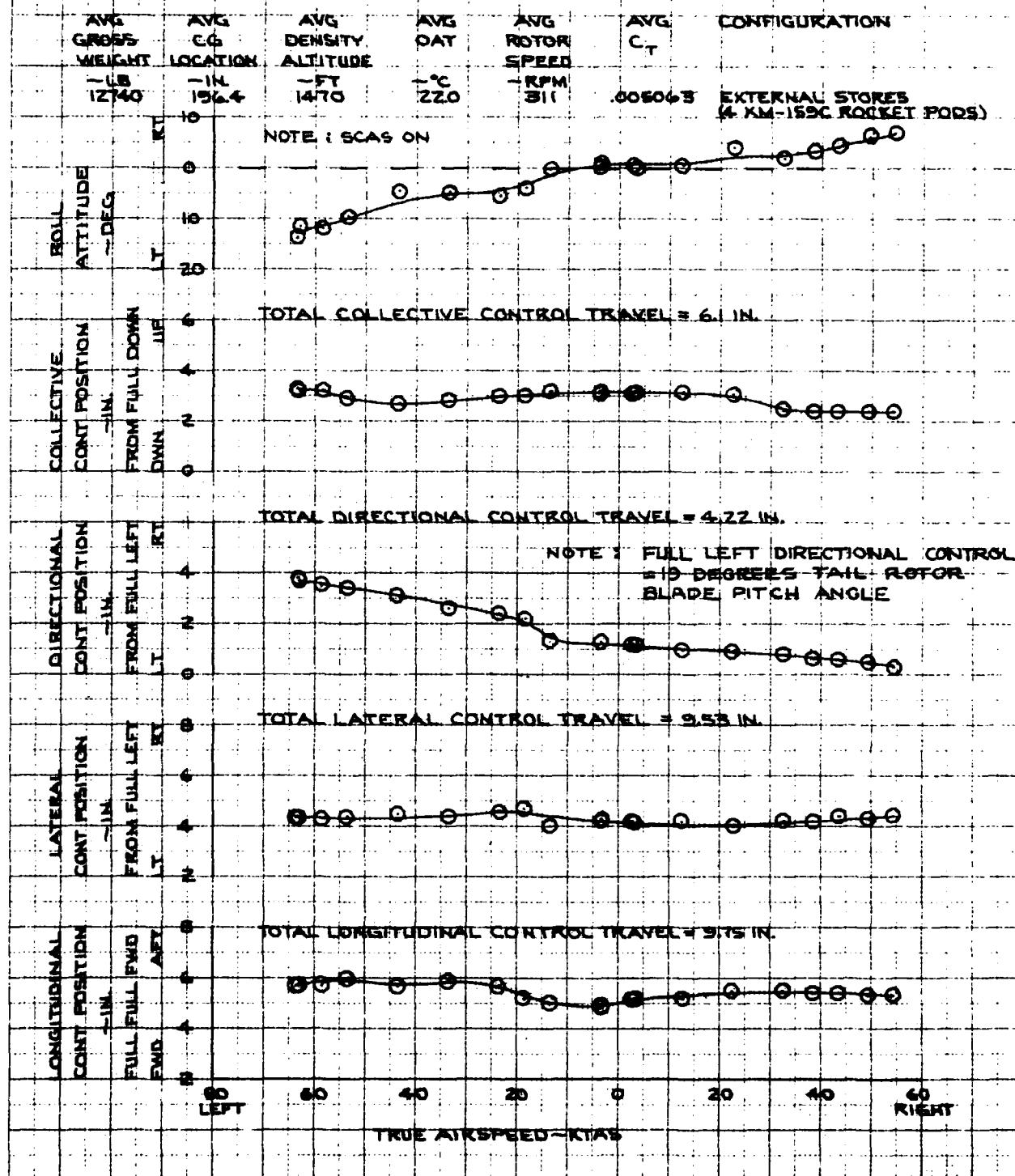


FIGURE NO. 16
CONTROL POSITIONS IN SIDEWARD FLIGHT
BELL MODEL 309, USA S/N N/A

Avg Gross Weight -lb	Avg CG -in.	Avg Density Location	Avg Altitude -ft	Avg OAT -°C	Avg Rotor Speed -RPM	Avg C _T	Configuration
12830	1968	9080	175	511	.006423		EXTERNAL STORES. (4 XM-159C ROCKET PODS)

NOTE : SCAS ON

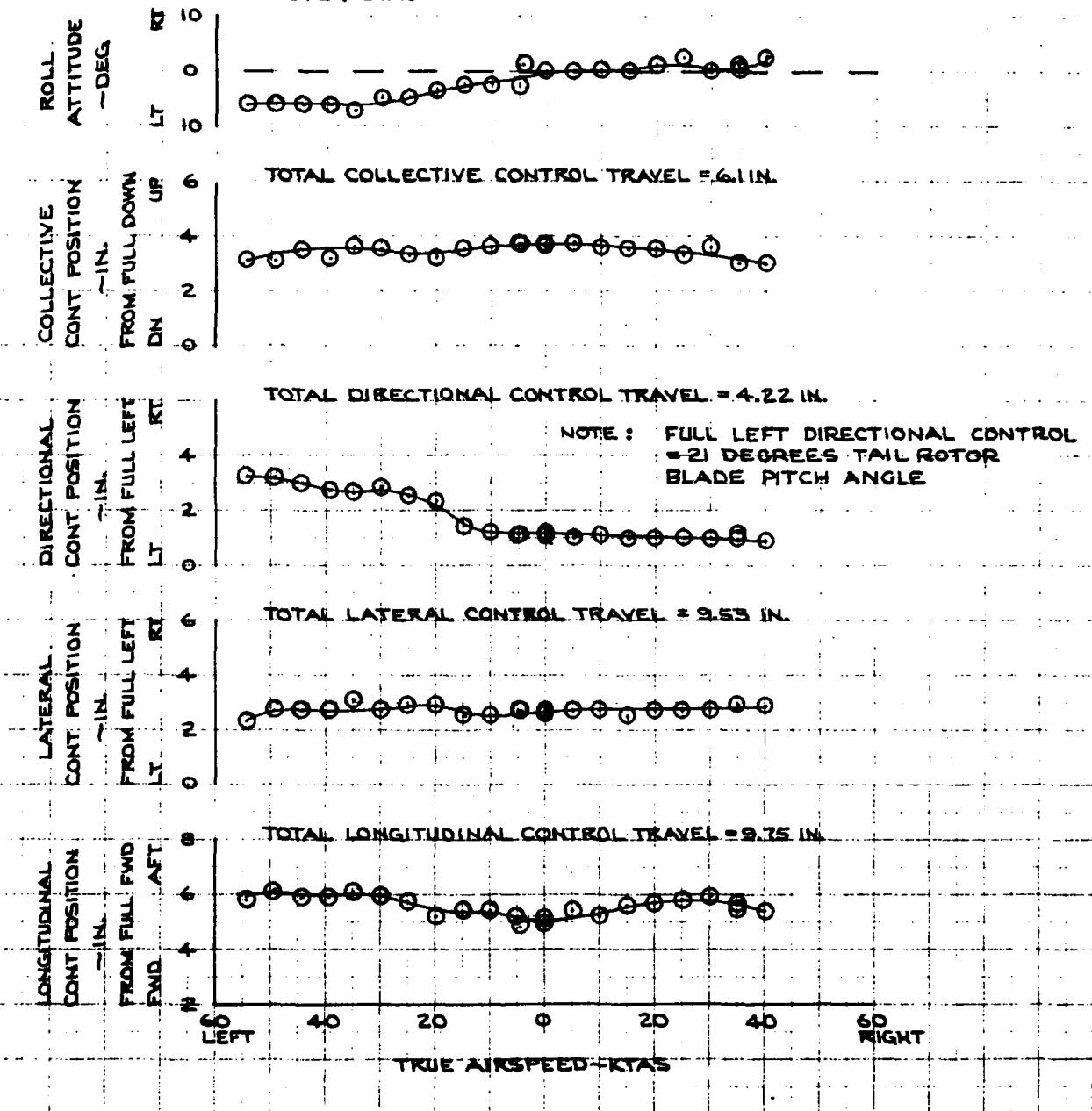


FIGURE NO. 17
AUTOROTATIONAL ENTRY
BELL MODEL 309, USA 5/4 N/A
LYCOMING ENGINE MODEL T55-L-TC 54 E-52(E)

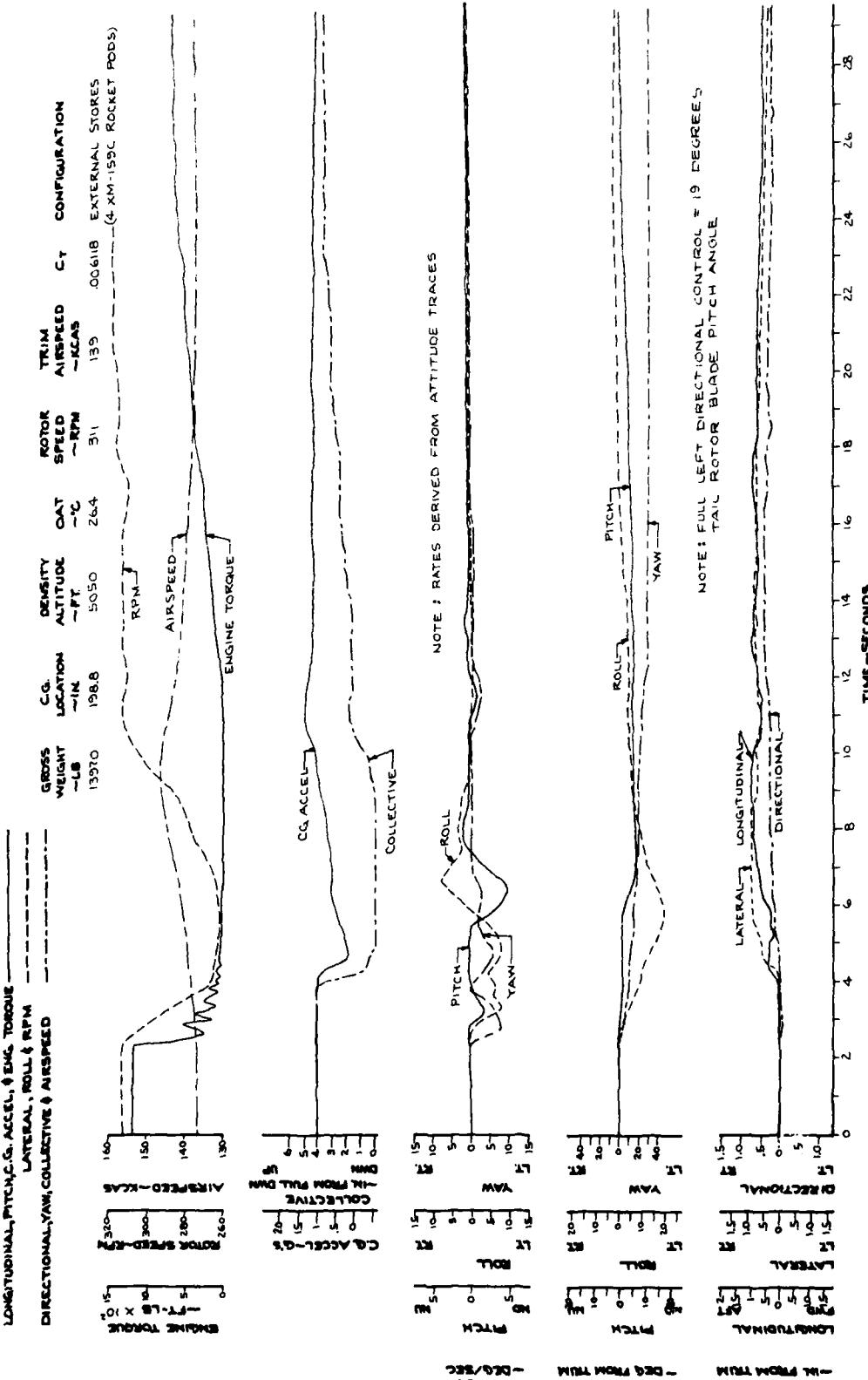


FIGURE No. 18
 AUTOROTATIONAL ENTRY
 BELL MODEL 303, USA 5% N/A
 LYCOMING ENGINE MODEL T55-L-TC 5% E-S(E)

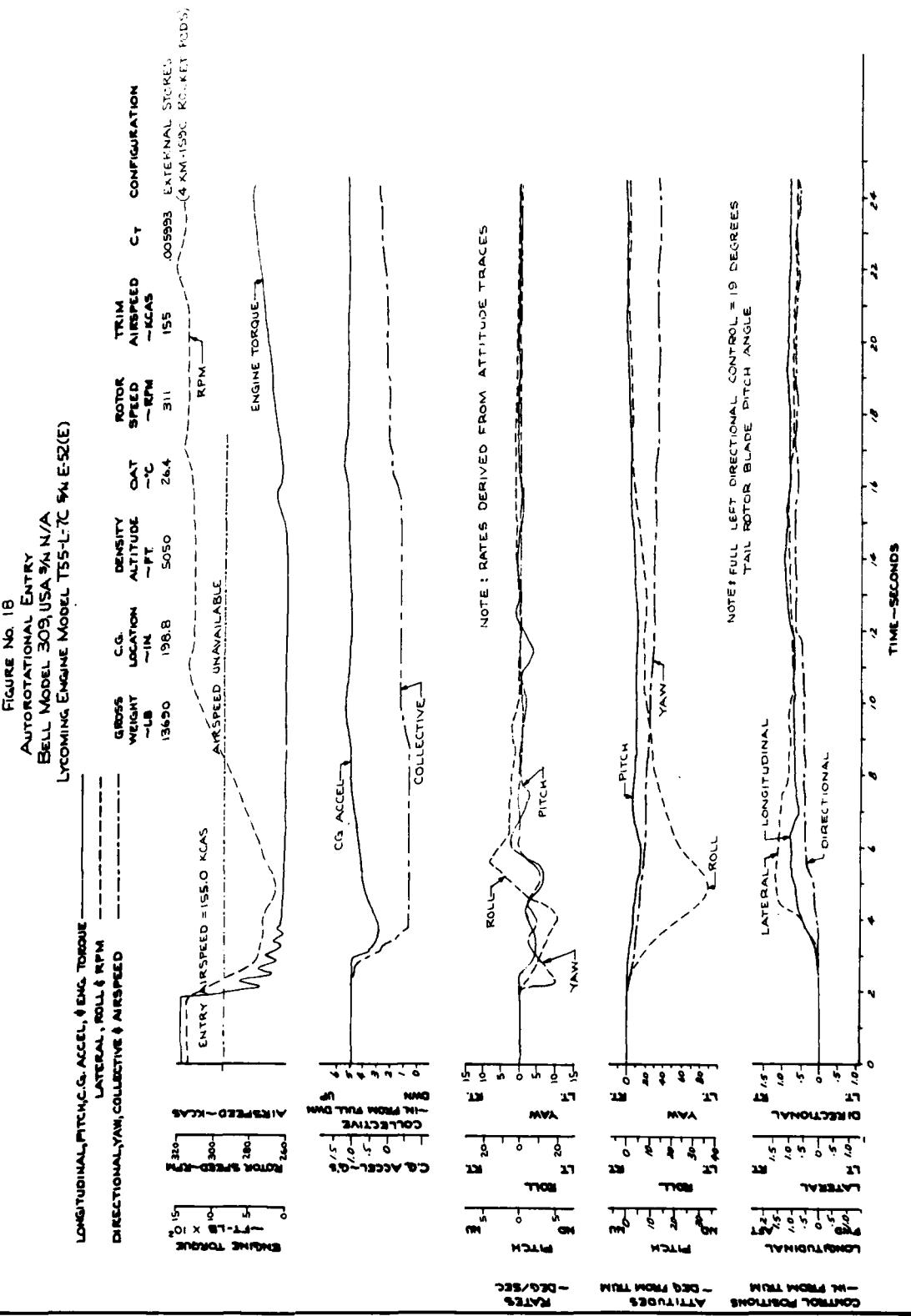
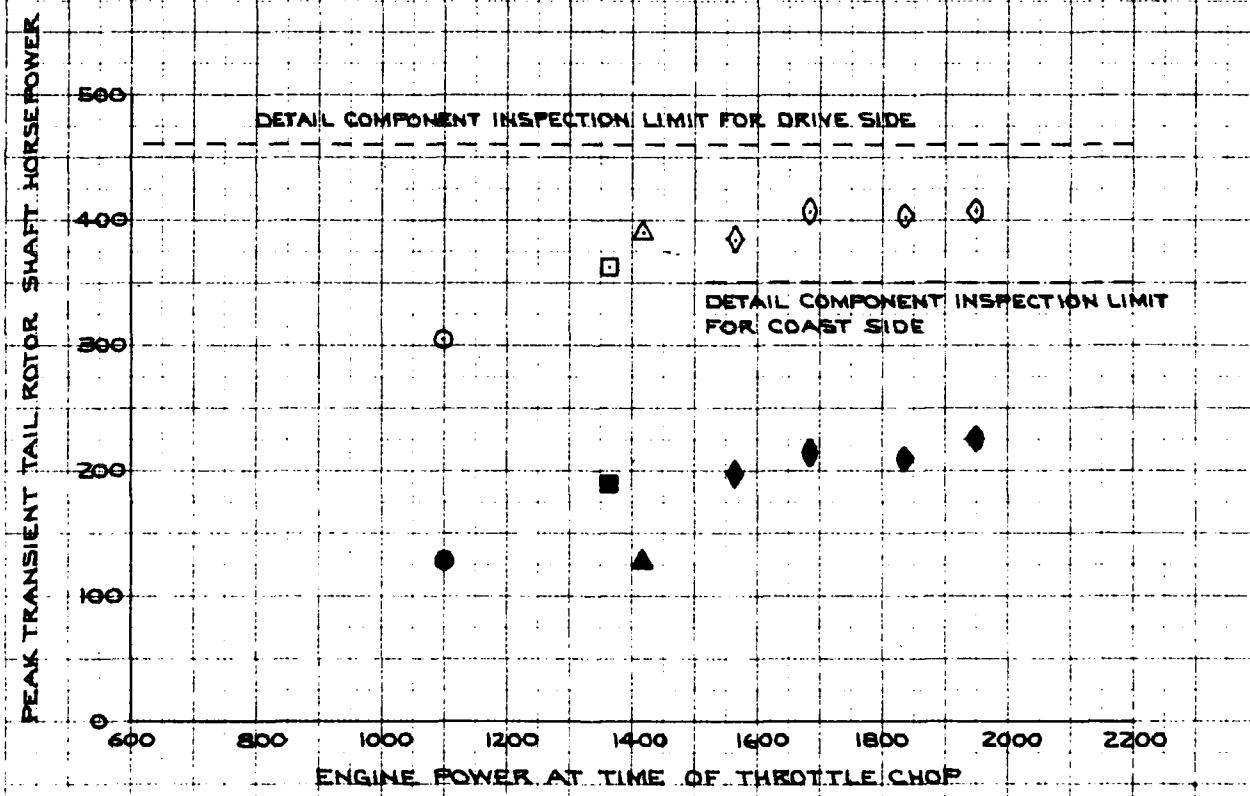


FIGURE NO. 15
THROTTLE CHOP SUMMARY
BELL MODEL 309 USA/SA/N/A

SYN ENTRY	Avg AIRSPEED	Avg GROSS WEIGHT	Avg CG LOCATION	Avg DENSITY	Avg GAT	Avg ROTOR SPEED	Avg C _T	CONFIGURATION
	-KCAS	-LB	-IN.	-FT	-°C	-RPM		
-	-KIAS	-LB	-IN.	-FT	-°C	-RPM		
○	114	13910	198.8	5600	27.0	311	.005887	EXTERNAL
□	133	13780	198.8	3670	26.5	311	.005852	STORES
△	135	14070	198.8	3850	27.0	311	.005452	(4 KN-155C ROCKET PODS)
◊	139	13970	198.8	5050	26.5	311	.006118	
○	142	13820	198.8	5050	26.5	311	.006094	
○	147	13795	198.8	5050	26.5	311	.006041	
○	156	13685	198.8	5050	26.5	311	.005893	

NOTES: 1)OPEN SYMBOL DENOTES DRIVE SIDE
2)SOLID SYMBOL DENOTES COAST SIDE
3)SCAS ON



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12 ABSTRACT

The US Army Aviation Systems Test Activity conducted a limited evaluation of the performance and handling qualities of the Bell Helicopter Company Model 309 helicopter at Arlington, Texas, and Alamosa, Colorado, a high-altitude site, during the period 11 July to 8 August 1972. The evaluation required 7 hours of flight time. Previous testing had been accomplished at the contractor's facility during the period 5 June to 6 July 1972 and a report was submitted. Except as noted in this report, the performance and handling qualities were essentially unchanged from those observed during the previous testing. The tail rotor horsepower limitation previously reported as a deficiency no longer exists due to an uprating of the tail rotor drive system from 350 to 450 shaft horsepower. The increase in sideward flight airspeeds to 60 knots in left sideward flight and 50 knots in right sideward flight at low altitude, and 50 and 40 knots in left and right sideward flight at high altitude, enhances the ability to hover in gusty winds. The standard-day out-of-ground-effect hover ceiling at the TOW mission gross weight of 12,385 pounds is 14,340 feet and at the maximum allowable gross weight of 14,000 pounds, is 9950 feet. The hot day (95°F) out-of-ground-effect ceiling is 4300 feet at maximum gross weight. Lateral acceleration maneuvers were conducted at both high- and low-altitude sites. Left lateral acceleration was limited by the transmission torque limit to 0.33g at the low-altitude site and 0.24g at the high-altitude site. Right lateral accelerations were limited by directional control to 0.28g and 0.14g at the low- and high-altitude sites, respectively. The helicopter response characteristics following simulated engine failures were significantly milder than that of the standard AH-1G and are satisfactory. One shortcoming, the excessive pilot workload during lateral accelerations and reversals, was identified.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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Limited evaluation Performance and handling qualities High altitude test site Increase in sideward flight airspeed enhances Out-of-ground-effect Characteristics following simulated engine failure						

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